



ARGEO PAUL CELLUCCI
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Lieutenant Governor

COMMONWEALTH OF MASSACHUSETTS
EXECUTIVE OFFICE OF ENVIRONMENTAL AFFAIRS
DEPARTMENT OF ENVIRONMENTAL PROTECTION
ONE WINTER STREET, BOSTON, MA 02108 617-292-5500

BOB DURAND
Secretary

LAUREN A. LISS
Commissioner

**Diesel Emission Control Retrofit Workshop
Washington, DC**

March 22/23, 2000

Massachusetts Diesel Retrofit Workshop

Presenter: Edward Kunce, Deputy Commissioner - MADEP
Preparer: Steven Lipman, P. E., Special Projects Coordinator - MPDEP

EXECUTIVE SUMMARY

Massachusetts Diesel Retrofit Program (MDRP)

MDKP is the primary component of the Massachusetts Mobile Source Emissions Control Program that responds to the need to control diesel emissions generated on-site by heavy-duty construction vehicles.

Construction vehicles contribute approximately 33% of mobile source PM and 10% of all NOx in the Northeast;

On-site control of vehicles used to construct the \$ 13 billion dollar Central Artery Tunnel Project;

"The Big Dig;" provided the forum for this program;

Program is applicable to ongoing infrastructure projects, even within highly developed cities and industrial areas.

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Public Health Impacts

Traditionally viewed as "nuisance conditions," public and private sector interest groups now agree that dust and odors generated by heavy construction have the potential for serious public health and worker impacts. On-site retrofitting addresses these problems directly at the source, improving air quality and "livability" for all exposed populations.

Field Implementation

A three-phase pilot was implemented in Boston through the cooperative efforts of state agencies, state authorities, NESCAUM, industry groups, and private contractors:

Phase I - retrofit of ten vehicles with oxidation catalysts;

Phase II - retrofit of fifty additional vehicles;

Phase III - retrofit of additional vehicles totaling approximately one hundred.

Retrofitted vehicles did not experience significant loss of power.

Engine manufacturers continue to honor engine warranties.

Costs

A joint cost-share was used by state agencies and private contractors to pay for the approximately \$2,000/vehicle retrofit, with the average cost of each vehicle being approximately \$2,500:

Retrofit costs range between \$1,000 - \$ 3,000/vehicle ;

No subsequent O & M retrofit costs;

\$ 3,000/vehicle translates into approximately \$ 1,000 per ton of contaminants/vehicle removed;

Economy of scale could drive equipment costs much lower over time.

Retrofit costs may be eligible for tax credits and incentives.

Air Quality Improvements

MDRP will reduce Central Artery construction emissions, particularly PM fine particulates, by approximately 200 tons over the next six years; an emission reduction equivalent to eliminating 96 million truck miles or removing 1,300 diesel-powered public buses for a year.

In addition to reducing PM, CO, and Hydrocarbons, oxidation catalysts and catalyzed particulate filters reduce toxic emissions of formaldehyde, benzene, acrolein, and 1-3 butadiene by as much as 70%.

MDRP will significantly assist efforts to address OSHA concerns for on-site worker health, particularly in below-grade areas, and will reduce overall project emissions of problematic contaminants.

Exposed populations will enjoy immediate benefits in improved air quality and overall "livability" in and around the ongoing construction in Boston.

Massachusetts Mobile Source Emissions Control Program

The Massachusetts Diesel Retrofit-Program [known as the Clean Air Construction Initiative (CACI)] plays a significant part in Massachusetts' multi-faceted approach to reducing emissions from mobile sources, which includes;

- (1) Adopted California's Low Emission Vehicles (LEV2) program in 1995 to increase the stringency of tailpipe emission standards;
- (2) Advocating for EPA to finalize a low sulfur gasoline requirement (which EPA eventually implemented);
- (3) Implementing heavy-duty diesel vehicle roadside testing;
- (4) Implementing an Enhanced Inspection and Maintenance (I & M) Program;
- (5) Expanding natural gas and electric bus and vehicle program; and
- (6) Retrofitting of Off-Road Construction equipment.

In the urbanized northeast, the air quality impacts from construction vehicles are significant; these machines contribute to approximately thirty-three percent of mobile source Particulate Material (PM) and ten percent of all Nitrogen Oxide (NOx) pollution. Over 90% of diesel engine particulate emissions are highly respirable and carry toxins deep into the lung. The U.S. Environmental Protection Agency has labeled PM a probable human carcinogen in a draft report and the California Air Resources Board has labeled diesel particulates a toxic air contaminant. Attachment No.1 is a "snapshot" summary of diesel emissions health effects.

Figures 1 and 2 are charts prepared by NESCAUM, which indicate the percentage of the toxics Acetaldehyde and Formaldehyde contributed by various types of mobile sources. In Massachusetts, for non-road diesel vehicles the percentage is 50% and 40% respectively.

The impetus behind the State's decision to aggressively develop a diesel retrofit program was the construction of the \$13 billion Central Artery/Tunnel (CA/T) Project, the alignment of which passes directly through the middle of downtown Boston in close proximity to dense residential areas and numerous sensitive receptors such as hospitals, daycare centers, parks/playgrounds, elderly housing, etc. (See figures No.3 through 11).

As integral aspects of the CA/T Project, the project proponent and DEP incorporated extensive construction mitigation actions dedicated to safe-guarding air quality, including; extensive use of construction vehicle detours, designated truck routes, no diesel truck idling, extensive dust control measures and cleanup of contaminated sites in the alignment. One missing element was a way to control diesel emissions from the hundreds of pieces of on-site heavy-duty construction equipment, particularly those generating "PM fine" particulates. (i.e. PM_{2.5})

In DEP's experience in overseeing and regulating large construction projects, the overwhelming majority of construction-period concerns and complaints relate to dust and odors affecting people living or working in close proximity to the active construction areas. Historically, these concerns were considered to be primarily "nuisance conditions." However, the public has become much more informed and sophisticated about the public health effects that may be attendant to these conditions; construction period diesel emissions being the items most often raised¹. This was the situation as active construction for the CAIT Project moved into the very dense residential development in Boston's North End.

In an attempt to find a practical and affordable control program that could be (1) implemented on-site and (2) could provide the flexibility necessary to a major ongoing infrastructure project, in 1998 DEP staff initiated discussions with the Northeast States for Coordinated Air Use Management (NESCAUM). DEP wanted to determine the potential for building upon the results of a pilot study NESCAUM had just completed at the U.S. Generating Co. Power Station in Salem, MA, whereby five pieces of on-site diesel equipment were retrofitted with various types of advanced pollution control equipment. Staff from NESCAUM and DEP subsequently met with representatives from the Massachusetts Turnpike Authority (MTA), who is managing the CA/T Project, and requested its active participation in performing an expanded pilot study on select CA/T equipment; initially ten (10) pieces of equipment were considered for the pilot.

The discussions with MTA staff and other relevant entities resulted in a November 8, 1998 official launching of the collaborative CACI, the sponsors being; USEPN Region I, Mass. Executive Office of Environmental Affairs (EQEA), Manufacturers of Emissions Control Association (MECA), MTA, NESCAUM and DEP, along with a number of participating CA/T contractors including; J.F. White Contracting Co., Jay Cashman, Inc., and Modern Continental Construction Company.

¹ Worker health is addressed later in this presentation.

Under the CACI, a two-phased plan was developed. In Phase I, ten (10) pieces of equipment would be retrofitted with control systems donated by MECA. In Phase II, implemented immediately after the Phase I retrofit, MTA would fund the retrofit of up to an additional sixty (60) pieces of equipment. The seventy (70) pieces would result in 25% of the permanent Central Artery construction equipment retrofitted with advanced pollution control devices.

Through this retrofitting effort, MTA would be reducing project emissions by approximately 200 tons of air pollutants over the remaining 4 to 5 years of the project, which is equal to reducing emissions from 96 million diesel truck mi-e3 or the removal of 1,300 diesel buses off Boston Streets for a full year. Oxidation catalysts and particulate filters are two of the control technologies that are being used in the Initiative. The equipment works by oxidizing particulates (PM), hydrocarbons (HC), and carbon monoxide (CO) to less harmful emissions such H₂O and CO₂. The equipment is also anticipated to reduce toxics such as formaldehyde and benzene by as much as 70%.

MTA is using a joint cost sharing procedure with its major contractors, with MECA and NESCAUM representatives working closely with CA/T staff to assist in implementation of the Phase II portion of the program. The estimated cost for the Phase II retrofit is approximately \$100,000, about \$2,500 per unit retrofitted. The CA/T Project is using mainly Oxidation Catalysts in its retrofit (figure 12 shows a CA/T crane with an oxidation catalyst). A typical price of a piece of diesel Off-Road Heavy Duty Construction Equipment will run at least \$250,000, making the \$2,500 retrofit cost insignificant. The typical cost for retrofitting engines with Oxidation Catalysts is \$1,000 to 3,000 depending upon the displacement of the retrofitted engine per unit. The CA/T costs are at the high end of this range due to the fact that MTA has chosen to retrofit the larger pieces of equipment.

While these costs are already relatively low, the price for both Oxidation Catalysts and Particulate Filters could drop considerably with economies of scale. Because there is currently no federal mandate for such emission control equipment, a large sustainable market has not yet developed. If a larger market develops, it is likely that the current price to retrofit an engine will drop. At even \$3,000 per retrofit, which translates into approximately \$1,000 per ton of contaminants removed, this is a very cost-effective and efficient means of emissions control.

The Oxidation Catalysts retrofit basically consists of a replacement engine muffler. Past studies indicate that there are no additional O&M costs and fuel use is typically not affected, therefore once the Oxidation Catalyst is installed there would not be any additional costs to the contractor. Also, DEP experience is that retrofitted equipment does not experience any significant "loss of power", which was a major concern for MTA and its contractors. Another significant concern of the contractors was whether engine manufacturers would continue to honor the engine warranties for retrofitted equipment. With the direct assistance of NESCAUM and MECA, this issue was fully resolved.

A secondary benefit from retrofitting the equipment at the CA/I Project, is that the retrofits "go-with-the-equipment"; therefore, additional air quality benefits will continue to occur over additional years at subsequent construction projects, dropping the cost per unit significantly over time².

At this time, MTA anticipates that the total Phases I and II retrofit program may consist of only 60 pieces of equipment and not the originally proposed 70. A third phase has been added, however, which will result in significant additional retrofitted diesel equipment, bringing the total to well over 100 units. This additional retrofit is being driven in large part by the need to meet OSHA requirements for worker health and safety during construction activities in the below-grade tunnel portions of the CA/I Project. This additional retrofit activity will not only allow for protection of worker health, but will also further reduce total project emissions and lower concentrations of problematic contaminants at and around the "glory-holes", which are access areas spaced along the entire CA/I alignment that allow for excavated soils to be removed from, and equipment and construction materials to be lowered into, the tunnels. Therefore, the total emission reductions will be considerably greater than originally anticipated.

Massachusetts has decided, at least for the present, to keep this program voluntary in that it tends to "sell-itself." Once the program is presented to project proponents and their contractors they are able to see that its implementation can cost-effectively reduce localized adverse impacts (significantly reducing complaints from project abutters and regulatory agencies) without any substantive adverse impacts to their project. The public relations benefits alone are well worth the cost of the retrofits.

This past November, DEP held a statewide workshop to provide a forum for sharing of information and experience in an attempt to expand the CACI to other large public or private infrastructure and development projects in the Commonwealth, particularly those in the Metropolitan Boston Area. Over forty individuals attended the workshop and DEP staff are currently working with a number of other State Agencies, the City of Boston, and private project proponents to expand the program.

In this regard, DEP has recently received commitments from a number of project proponents [e.g. Mass. Bay Transportation Authority (MBTA), Massachusetts Port Authority (Massport), Massachusetts Water Resources Authority (MWRA) and Massachusetts Highway Department (MHD)] to include diesel retrofit requirements into future construction projects; specific examples include:

- (1) Massachusetts Highway Department's \$300 million 45-mile Route 3 north of Boston widening and reconstruction project, and
- (2) Massachusetts Port Authority future contracts for the \$3 billion Logan Airport Modernization

² Based upon recent IRS Advisory Opinions (97-83 AOP (Sept.1997) costs of a voluntary retrofit may be eligible for long-term depreciation and/or time-limited tax credits.

Program, and its tenants and their contractors for the billion-dollar revitalization of the South Boston Seaport Area.

As part of its Coordinated Air Quality Pollution Prevention Strategy, the State is considering requesting that all large State contracts include the condition that a certain percentage of the on-site heavy duty construction equipment have advanced emission controls.

DEP has also been actively using the Massachusetts Environmental Policy Act (MEPA), the state version of the National Environmental Policy Act (NEPA), project review process to provide information about the CACI to proponents of large construction projects. The Executive Office of Environmental Affairs, through its MEPA Office, has been instrumental in incorporating the inclusion of diesel retrofit technologies into large construction projects by including DEP's recommendations into Certifications for the projects.

DEP believes that, if possible, it is much better to get project proponents to include retrofit technologies directly into their construction specifications, versus attempting to incorporate retrofits into ongoing construction. By affirmatively including upfront retrofits, particularly for projects that are competitively bid, the "additional costs" for the retrofit control technology and invoiced in the overall bid package, the result being that the project proponent would not see an additional project cost for this item.

In conclusion, DEP believes that retrofitting of on-site heavy-duty construction equipment is a very cost-effective and efficient way to significantly reduce emissions of fine particulates and toxics into the ambient air, to mitigate adverse localized impacts, and improve the air quality for construction workers, while not adversely affecting the construction phase of major construction and development projects.

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A "snapshot" regarding diesel health effects

- Diesel engines emit high levels of nitrogen oxides (N Ox) and particulate matter (PM), and in addition, a complex mixture gases many of which are known or suspected cancer causing agents.
- Nitrogen oxides are ozone and secondary fine particle precursors. Ozone is a highly irritating gas that produces short-term adverse health effects including coughing, shortness of breath and decreased lung function. These effects range from temporary and reversible impairments to potentially irreversible lung damage.
- Diesel exhaust is an important contributor to airborne concentrations of fine particle pollution, especially in urban areas.
- Diesel exhaust is a significant contributor to airborne levels of a number of hazardous air pollutants of concern (especially formaldehyde/acetaldehyde).
- Recent health effects studies have shown an association between existing levels of PM and health effects such as premature mortality from respiratory and cardiovascular disease and increased incidence of respiratory illness in exposed populations. In one major study, the risk of mortality in cities with the highest levels of fine particulate pollution was approximately 15 to 25% higher than in cities with the lowest particulate levels. *The elderly and children were identified as the most "sensitive" members of the population.*
- Several national and international organizations classify diesel exhaust as a probable human carcinogen. The US BPA has proposed classifying diesel exhaust as "highly likely to be carcinogenic to humans." The California Air Resources Board has designated diesel exhaust particulate matter as a toxic air contaminant.
- A recent air monitoring and public health risk characterization study in California concluded that diesel exhaust was responsible for ¾ of the total potential public health risk associated with air pollution. As a result, the South Coast Air Quality Management District is developing regulations to force certain vehicle fleets (especially trucks) to use fuels other than diesel.